A Multi-layer Conceptual Framework for Circular Economy Integration in Cold Climate Construction Policy in Canada

Canada's construction sector generates approximately 4 million tonnes of construction, renovation, and demolition (CRD) waste annually, while extreme cold-climate conditions, including freeze-thaw cycles, permafrost, and severe thermal loads, compound material degradation and reduce building lifecycle performance. Despite growing interest in Circular Economy (CE) principles as a governance response to these pressures, there is a limited number of integrated frameworks that currently combine CE policy analysis with cold-climate construction performance requirements in the Canadian context. This study addresses that gap by proposing a multi-layer conceptual framework for CE integration across all 13 Canadian provinces and territories. A qualitative comparative policy analysis was conducted using a critical document review based on the ReSOLVE- and 3Rs-based framework coding applied systematically across all Canadian jurisdictions. Provincial and territorial policies were evaluated to examine patterns, gaps, and areas of convergence. The findings reveal significant interprovincial fragmentation in CE policy development. To illustrate, while Quebec demonstrates high CE framework maturity through a formal CE roadmap with regulatory backing, most provinces remain at an emerging stage, limited to basic waste diversion without lifecycle governance. Northern territories face compounded barriers, including absent C&D material regulation, limited recycling infrastructure, and logistics constraints unique to remote cold-climate regions. Based on qualitative comparative policy analysis, the research proposes a framework that integrates governance architecture, cold-climate performance requirements, and the full ReSOLVE lifecycle from pre-design to end of life into a multi-layer model supported by a Decision Gateway for circular material recovery. This research contributes an analytical architecture that policymakers, construction practitioners, and researchers can use to identify intervention points, align provincial regulations with national sustainability objectives to advance the Sustainable Development Goals (SDGs): (SDG 13 Climate Change) and CE adoption in one of the world's most climate-challenging built environments.

Keywords: *Circular Economy, cold-climate construction, Canadian energy policy, comparative policy analysis, ReSOLVE framework, lifecycle assessment, construction waste governance.*

Introduction

Background: The Construction Industry

Construction represents a large and increasing portion of Canada's national greenhouse gas emissions and landfill waste. The buildings and construction industry is responsible for around 37 percent of the world's global greenhouse gas emissions, and embodied carbon of materials like cement, steel, and aluminum is a burgeoning and under-addressed element of the Buildings and Construction industry (United Nations Environment Programme and Global Alliance for Buildings and Construction) (UNEP & GlobalABC, 2023). Construction, renovation, and demolition (CRD) activities in Canada generate about 4 million tonnes of waste per year, or almost 12 per cent of all solid waste generated in the country, and they account for more than seven per cent of the nation's GDP and over 1.5 million Canadians (Environment and Climate Change Canada, 2024; The Environment Journal, 2024). Although CE principles are gaining traction as a form of governance response, the application of CE practices in Canadian construction and energy policies is inconsistent, fragmented, and largely confined to downstream waste management, and not upstream governance during the lifecycle of a product or service (Mullock, 2025; Rajaonson, 2025).

This imbalance between the upstream and the downstream is a structural issue. That's in a 2025 working paper from the Smart Prosperity Institute that mapped Canada's CE policy landscape and revealed the national rate is a mere 6.1 percent, which is significantly lower than the global average of 8.6 percent and much lower than 30.6 percent for the Netherlands, which has had an effective CE policy for a long time. Overall, a majority of policies, identified across federal, provincial and municipal levels (122 policies), were directed towards waste collection and recovery, but not product design, material passports, fiscal incentives or brokerage platforms (Mullock, 2025). This, in turn, is indicative of a trend; policy rhetoric across federal and provincial levels has been mainly about the environment and not taken on a strategic and economy-wide lens, thus creating disjointed and less harmonized policy across jurisdictions (Rajaonson, 2025).

Two Structural Challenges

Two structural challenges compound Canada’s CE implementation gap in the construction sector. First, Canada’s decentralized governance model means that construction and environmental policy is largely determined at the provincial and territorial level, resulting in wide disparities in CE framework maturity across jurisdictions. Jurisdictional complexity prevents the economies of scale necessary to justify domestic processing and the retention of material value (Mullock, 2025). While provinces such as Quebec have developed formal CE roadmaps with regulatory backing and dedicated funding, and British Columbia has embedded embodied carbon reporting requirements in municipal building bylaws, most provinces and all three territories remain at an exploratory or emerging stage. Critically, there are currently no national or provincial building codes that formally address reduction of CRD waste or mandated incorporation of recycled content in construction (Government of Canada, 2024).

Second, existing CE policy frameworks fail to explicitly address the unique physical challenges of building in cold climates, such as the degradation of materials with freezing and thawing, the high thermal load, requirement for material moisture management, snow load resistance, instability of permafrost, and supply chain logistics in northern regions (Hutcheon & Handegord, 2023; Luo et al., 2022). Spalling, cracking, and delamination are common issues in masonry and concrete assemblies that are caused by repeated freeze-thaw cycles, which lead to material failure and more material replacement, directly challenging CE goals of material longevity and lifecycle extension (Duffy Engineering, 2025). For northern and remote communities, the lack of recycling infrastructure and reverse logistics networks is an additional material disadvantage, near to zero, as even in the context of circular aspirations, the physical systems in place to support them don't exist (Government of Canada, 2024).

The Policy-Climate Integration Gap

Taken together, these challenges reveal a clear and largely unaddressed gap in both the academic literature and Canadian policy practice: there is a limited number of integrated frameworks that currently exist that simultaneously account for CE governance principles and cold-climate construction performance requirements in the Canadian context. The current research base on CE generally distinguishes between governance and technical performance and has yet to develop a system of coding and analyzing Canadian policies against a set of standardised CE criteria across jurisdictions. In October 2025, Circular Economy Leadership Canada and Circular Innovation Council released the Circular Economy Action Plan for Canada 2.0, which documents some of the gaps in CE infrastructure, the absence of a national CE standards framework that aligns with building codes, and the need for a clear federal roadmap for the systematic adoption of CE in construction (Circular Economy Leadership Canada & Circular Innovation Council, 2025). According to a first review of CE adoption in the construction sector by Frontiers in Built Environment (2025), there are no standards for the use of secondary materials, weak enforcement of environmental regulation for CRD waste, and no regulatory framework that is sensitive to climate and geography that can support the implementation of CE in different national contexts (Aghimien et al., 2025).

Study Contributions and Research Question

This paper responds directly to these gaps by presenting an integrated governance and lifecycle framework that integrates CE principles with cold-climate construction performance requirements across all 13 Canadian provinces and territories. The research is guided by the following questions:

RQ1: What are the differences in how the circular economy is implemented in construction policies across provinces in Canada?
RQ2: What are the policy gaps to address to support implementation of CE in cold climates?
RQ3: How can the insights derived from the policy analysis be integrated into a governance framework that supports CE?

Literature Review

Literature is examined within the ReSOLVE framework (Regenerate, Share, Optimize, Loop, Virtualize, Exchange) (Carra & Magdani, 2017) to assess the cross-sectoral potential for implementing circularity in construction. While the 3Rs (Reduce, Reuse, Recycle) are important, they form a subset of ReSOLVE (Ghisellini et al., 2018).

Shallow Policy Analysis

Shallow Policy analysis is an analysis of the policies that is non-critical and superficial in nature. Nevertheless, the policy suggestions might not be in line with the wider CE Goals like integration of renewables, digitalization, and shared infrastructure (Ghisellini et al., 2018). An example is a provincial construction policy which may suggest that the buildings should be made of recyclable materials, which clearly sounds like a good move towards sustainability. However, if the policy does not require those materials to be reused, tracked, and connected to a larger ecosystem, then the impact is very limited. We can refer to Ontario's building code Restrictions on Reuse. According to the Government of Ontario (2017), "*Used materials and equipment shall not be reused unless they meet the requirements and are otherwise satisfactory for their intended use*." The said code permits used materials to be utilized if they undergo the requirements of the present-day code, but on the flip side, it does not encourage or dictate the use of recycled materials. However, the ReSOLVE framework ensures that CE Strategies are fully evaluated.

Lifecycle Optimization

Lifecycle optimization can be defined as a continuous effort to enhance the environmental, economic, and functional performance of a product throughout the product life. These are the major phases: design phase, production phase, use phase, and end-of-life phase. For example, lifecycle optimization in construction could refer to the selection of materials with the ability to survive cold freeze-thaw cycles to limit deterioration or the creation of buildings that can be broken down to reuse materials. Thus, the literature is further examined based on the lifecycle optimization framework that will assist us in determining whether CE Strategies cover the entire material and building lifecycle from design to the end of life.

Some previous studies have emphasised the relevance of adopting lifecycle thinking in the implementation of the Circular Economy in the construction sector. The design of buildings to be disassembled, recovered, and reused is essential to effectively lower construction and demolition waste while at the same time enhancing the environmental and economic performance of the buildings. (Mazzi & Gatto, 2020) Likewise, Estrada and Lee (2023) emphasized the need to take embodied energy, carbon footprint, and Life Cycle Assessment (LCA) into account when optimizing the life cycle of products; and support the use of recycled materials, material reuse, and design for adaptability. All these studies show that a holistic approach to sustainability over the whole building life cycle is necessary to implement an effective Circular Economy.

Circular Economy Policy Gaps in Canada

The implementation of circular economy (CE) principles varies significantly across markets, creating a need for sector-specific and customized solutions (CSA Group, 2024). Moreover, there is no one national CE policy framework in Canada yet, and the existing adoption of the CE principles remains at the level of material waste management, adopting a site-based, contractor-centric strategy, which does not consider stakeholder participation, process integration, or cross-sectoral flows of resources (Jayakodi et al., 2024). This paper will provide evidence-based suggestions to include CE in energy and construction policy through review as well as comparison to fill these gaps in implementation. Although a wide understanding of the significance of CE exists, there is a lack of a critical comparative study that focuses on the integration of CE principles in the policies of the Canadian provinces of construction and energy, especially for cold-climate residential buildings. The proposed research is a direct answer to this gap as it examines the cross-provincial policy of CE comparison and designs an integrated framework of CE adaptation to the conditions of cold climate. In addition, sustainability objectives to advance the Sustainable Development Goals (SDGs): SDG 13 Climate Change.

Methodology

Research Design

This study adopts a qualitative comparative policy analysis design supported by critical document review and framework-based coding. It is useful to use qualitative comparative analysis (QCA) when: (a) the number of cases is too large to be studied in depth using single-case analysis, but too small and varied to allow for statistical generalization; (b) the research aims to examine how combinations of conditions, rather than single conditions, create or hinder an interesting outcome; and (c) the evidence base for the research is primarily policy documents or legislative texts, not survey data or experimental data (Rihoux & Ragin, 2009; Peters, 2013). This study is a case of all three: It examines CE policy integration in all 13 Canadian provinces and territories.

The research question is clearly interpretative in nature because it goes beyond simply determining whether CE policies exist, to also inquire about their structure, their omission, and why they are not put into practice. The core strength of qualitative comparative methods (QCM), as proposed by Flyvbjerg (2006) and Rihoux & Ragin (2009), is the use of analytical judgment when making judgements based on rich textual evidence, and this is precisely what is required here. A secondary data approach was chosen, as the evidence base on government documents, legislative instruments, and provincial strategies, which are publicly available, institutionally authoritative, and directly address the governance phenomena under investigation, is readily available. This approach is consistent with established practice in CE policy research: Piscicelli et al. (2024), in their systematic review of CE public policies, relied entirely on document analysis of policy texts; similarly, Abu-Bakar and Charnley (2025) conducted a large-scale CE policy analysis across the United Kingdom using documentary sources without primary data collection.

Conceptual Framework

The analytical foundation draws on two established CE frameworks applied in combination. The ReSOLVE framework (Regenerate, Share, Optimize, Loop, Virtualize, Exchange), developed by the Ellen MacArthur Foundation (2015) and operationalized for the built environment by Carra and Magdani (2017), provided the primary lens for identifying specific policy elements within each jurisdiction. The 3Rs framework (Reduce, Reuse, Recycle) was applied as a complementary lens, particularly for assessing waste management policies and identifying where provinces remain limited to basic waste diversion without broader circular governance (Ghisellini et al., 2018). Together, these frameworks generated a structured coding guide (Table 1) that ensured consistency and comparability across all 13 analyses.

Table 1. *ReSOLVE Framework and 3Rs Coding Guide*

ReSOLVE / 3Rs Dimension	Policy Coding Guidance
Loop	Policies that encourage material reuse, recycling, and deconstruction requirements in the built environment.
Optimize	Policies promoting energy efficiency and improvements in lifecycle performance.
Share	Policies implementing shared infrastructure, material exchange markets, or community reuse programs.
Regenerate	Policies focused on renewable energy integration and low-carbon resource substitution.
3Rs (Reduce / Reuse / Recycle)	Policies emphasize waste reduction, material reuse, and recycling pathways as complementary baseline lens.

Research Phases

The research proceeded in two sequential phases, each contributing a formal deliverable as shown in Table 2.

Table 2. *Research Design and Phase Structure*

Phase	Description	Deliverable
Phase 1: Policy & Literature Review	Federal and provincial construction and energy policies reviewed to evaluate the regulatory environment for CE adoption across all 13 Canadian jurisdictions.	Cross-provincial comparative policy analysis
Phase 2: Framework-Based Coding	Provincial policies coded using the ReSOLVE and 3Rs frameworks. Six standardized criteria applied consistently across all jurisdictions to enable comparative analysis.	Conceptual research framework

Data Collection

Sources were identified through structured web-based searches combining thematic CE terms with provincial or territorial identifiers (e.g., "Circular Economy policy in Manitoba," "Construction waste regulation British Columbia pdf"). This province-by-province approach ensured policy evidence was gathered consistently across all 13 jurisdictions. Sources were included if they were directly relevant to CE policy, construction waste management, or energy policy in a Canadian provincial or territorial context; published by a government body, recognized research institution, or peer-reviewed journal; sufficiently detailed to allow framework-based coding; and available in the public domain.

To enhance the comparative analysis, policy documents from several authoritative sources were gathered, such as Circular Economy (CE) strategies, construction and environmental policy reports, building codes, peer-reviewed academic publications, and federal and provincial government legislation. Multiple documentary sources allowed data triangulation and decreased the chance of bias from using one source for the policy review, while increasing its comprehensiveness.

Data Analysis

Three analytical steps were applied sequentially. Step 1 involved policy coding using the ReSOLVE and 3Rs frameworks against specific, concrete policy elements in each jurisdiction where no identifiable CE construction policy existed (e.g., Nunavut); absence was explicitly coded as a policy gap. Step 2 cross-referenced findings from each province against multiple sources to ensure consistency and reduce interpretive bias. Step 3 synthesized all findings into the conceptual framework.

The comparison exercise involved applying the same analytical criteria across all 13 Canadian provinces and territories, including policy instruments, construction-specific implementation of the CE process, integration of the CE process into the lifecycle, consideration of cold climates and overall maturity of the CE process. By applying the same criteria of evaluation in every jurisdiction, the analysis was kept consistent, transparent and comparable.

Key Results

The analysis of the Canadian provinces shows that the implementation of the circular economy (CE) in the construction sector is still not uniform throughout the country. Whereas the majority of provinces have implemented waste diversion, recycling, and Extended Producer Responsibility (EPR) programs, these have generally only focused on municipal solid waste and consumer products, not construction and demolition (C&D) materials. Ontario and British Columbia have started to take more steps than Quebec does in terms of legislation and policy, and Quebec has the most robust provincial CE framework. All provinces, however, still have a long way to go in the integration of circular principles into building codes, construction procurement, material management throughout the building's lifecycle, and design-for-deconstruction. Pockets of progress have been made in waste management across Alberta, Saskatchewan, Manitoba, Newfoundland and Labrador, and the Atlantic provinces, but there is a lack of dedicated circular economy frameworks for construction activities; the northern territories have other barriers to success in waste management, including limited infrastructure, geographic isolation, and reliance on imported construction materials.

Multi-Layer Conceptual Framework

The primary analytical contribution of this study is a multi-layer conceptual framework that integrates governance mechanisms, climate-specific performance requirements, and circular lifecycle principles into a coherent model for cold-climate construction policy in Canada. The framework is structured across five interdependent layers, as illustrated in Figure 1.

Layer 1: Governance and Policy Architecture

At the top of the framework, Policy and Government Architecture represents the primary institutional driver of circular construction. This layer is activated by two external enablers. The Government Enabler encompasses provincial roadmaps, municipal implementation, and code and standards alignment. The Economic Enabler encompasses grants, Extended Producer Responsibility (EPR) mechanisms, landfill pricing, procurement guarantees, and carbon pricing. Together, these enablers supply the regulatory and financial conditions necessary for CE adoption. Key policy instruments identified within this layer include CE roadmaps and strategies, building code alignment, public procurement regulations, carbon pricing and innovation incentives, extended producer responsibility mechanisms, and inter-ministerial coordination. The absence or weakness of any of these instruments, as seen across most Canadian provinces, directly limits the effectiveness of circular construction systems.

Layer 2: Comparative Policy Analysis and Policy Gaps

Beneath the governance layer, the framework incorporates a Comparative Policy Analysis component representing the methodological strategy of this study. This is the part that measures alignment of provincial policies, differences in regulations, and the gaps in governance structure of the 13 Canadian jurisdictions. At the same time, a Policy Gaps and Barriers component documents the structural barriers which hinder CE implementation: lack of regulation of construction and demolition (C&D) material; limited recycling infrastructure; policy fragmentation between the provinces; and logistics barriers in northern Canadian regions. These two components are interdependent; comparative analysis reveals the gaps, and the gaps, in turn, justify the need for the integrated framework proposed here.

Layer 3: Cold-Climate Performance Requirements

One of the keys and most innovative aspects of this framework compared to other models of CE governance is the clear integration of Cold-Climate Performance Requirements as an analytical layer in the middle of the framework. This layer specifies the following environmental and technical characteristics of northern Canadian construction: resistance to frost and thaw, durability, water resistance, extreme environment, snow load, and thermal performance. They affect the choice of materials, buildability of the building envelope, and life cycle sustainability. More importantly, they limit the ability to apply typical CE methods to their application, such as design-for-disassembly strategies potentially conflicting with durability needs in permafrost environments and local recycling facilities not always being available in remote northern communities. There is a strong emphasis on the framework as a policy-design guideline. Cold climates are not simply an afterthought but are built into the framework.

Layer 4: ReSOLVE Lifecycle Implementation

The operational aspects of the framework are mapped to the complete building life cycle: Pre-Design, Design, Procurement, Construction, Operations and Maintenance, Renovation and End of Life. The lifecycle perspective is used here to highlight that CE values need to be implemented in all phases of the construction process and not just during waste processing. Within the lifecycle flow, there are two decision points, one at the procurement and construction stage (Recovery System checkpoint) and one at the renovation and end-of-life stage (Recycling Locally checkpoint). These checkpoints are linked to a Circular Waste Hierarchy of Prevent, Extend Life, Reuse, Remanufacture, Recycle, Recover Energy and Dispose. The hierarchy implements the concept that strategies for conserving material value should always be considered before strategies of energy recovery or final disposal.

Layer 5: Empirical Evidence and Enabling Systems

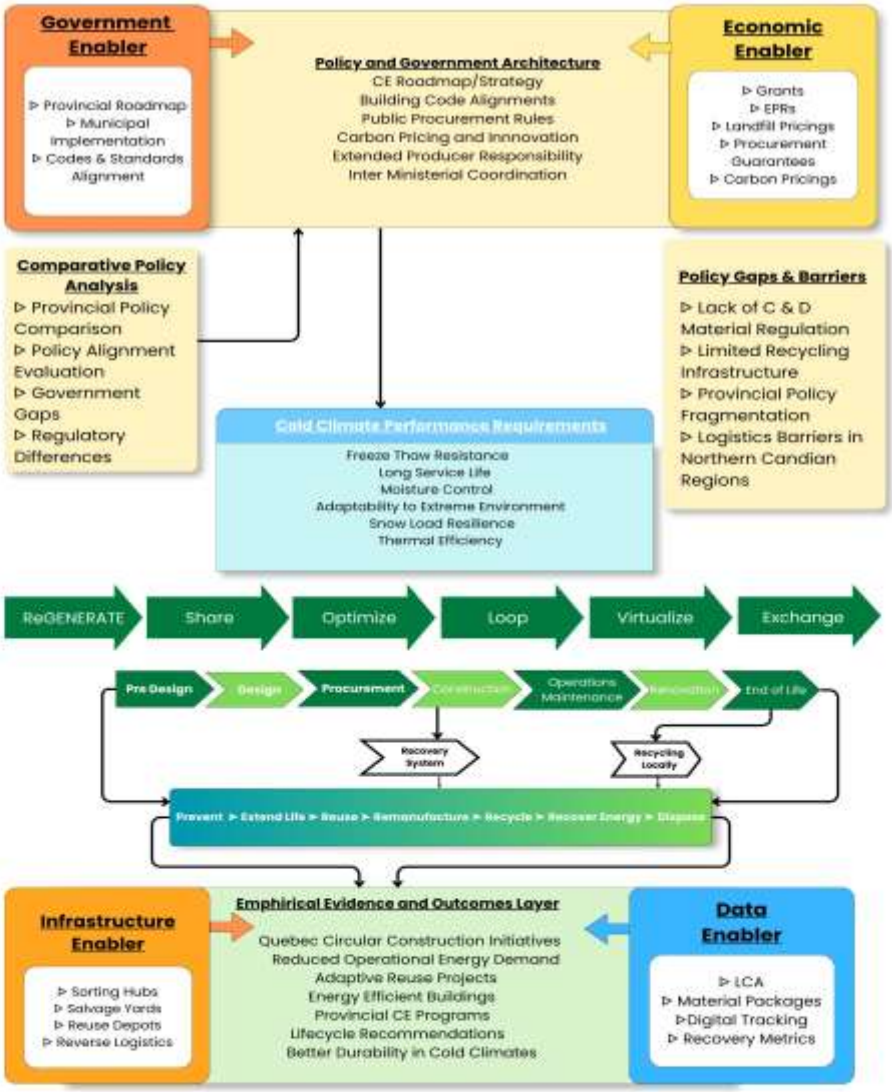
The bottom of the framework connects circular governance to measurable outcomes through an Empirical Evidence and Outcomes Layer, anchored in documented Canadian CE construction initiatives: Quebec's circular construction programs, adaptive reuse projects, energy-efficient buildings, and provincial CE programs. These outcomes are framed in terms of key performance deliverables: reduced operational energy demand, lifecycle recommendations, and improved durability in cold climates. Two enabling systems support the outcomes layer. The Infrastructure Enabler identifies the physical systems required to enable circular material flows: sorting hubs, salvage yards, reuse depots, and reverse logistics networks. The Data Enabler identifies the analytical tools required to monitor and evaluate circular performance: lifecycle assessment (LCA) tools, material passports, digital tracking systems, and recovery metrics. Both enablers are currently underdeveloped in most Canadian jurisdictions, representing a critical implementation gap.

Framework Synthesis

The four dimensions of governance mechanisms, climate-specific demands for performance, circular approaches to the lifecycle of the built environment, and empirical evidence have been connected into a single framework that demonstrates how CE principles can be systematized and applied in cold climate construction contexts. The framework is not a policy template for implementation; rather, it is a framework for analysis: it illustrates the interconnections between the inputs in policy, environmental constraints, policy lifecycle decisions and sustainability impacts, and opens the door for policymakers and researchers to understand where policies need to be most useful and most effective.

The main premise of the framework is that Canadian construction must be aligned with its governance aspects on the provincial and federal level, the technical design of infrastructure must be tailored to meet the requirements of a cold climate, and infrastructure and data systems need to facilitate circular material flows on a large scale.

Figure 1. *Circular Economy Governance and Lifecycle Framework for Cold-Climate Construction Systems.*



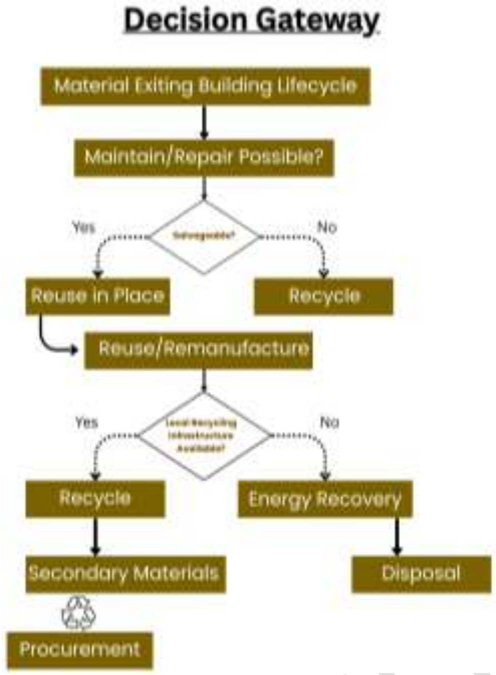
Source: Authors

Decision Gateway for Circular Material Recovery

Complementing the governance framework, Figure 2 presents a Decision Gateway that operationalizes the circular waste hierarchy at the point when construction materials exit the building lifecycle through renovation, maintenance, or demolition. The gateway follows a sequential assessment logic prioritizing the highest-value recovery option at each stage.

The process begins by asking whether maintenance or repair is possible if so, materials are reused in place, extending service life with minimal resource impact. If not salvageable in place, materials proceed to reuse or remanufacture. Where local recycling infrastructure exists, materials enter recycling systems and re-enter the supply chain as secondary materials feeding back into procurement. Where infrastructure is absent, a common condition in Canada's northern territories, energy recovery is pursued before disposal as a last resort. This gateway directly addresses the infrastructure gap identified across most Canadian jurisdictions and provides a practical decision tool for construction managers, policymakers, and waste planners operating under cold-climate constraints.

Figure 2. *Decision Gateway for Circular Material Recovery in the Building Lifecycle*



Source: Authors

Framework Validation

A preliminary expert validation of the proposed framework was conducted with 10 subject matter experts with backgrounds in Circular Economy, construction management, sustainability, building regulations, and public policy to enhance the credibility of the proposed framework. The experts have been selected based on their academic peer-reviewed publications and experience in Circular Economy and sustainable construction, and at least five years of experience. The proposed framework was independently assessed by experts, who provided qualitative comments on clarity, applicability, completeness, and practical relevance. Qualitative feedback was assessed using thematic analysis to identify common themes and recommendations, which were used to inform the refinement of the final framework based on the feedback.

The thematic analysis of the expert feedback identified five themes: policy applicability, governance integration, lifecycle integration, cold climate considerations, and implementation feasibility. The experts noted that the framework offers a comprehensive and practical way to implement the principles of Circular Economy in Canada's construction sector, which faces distinct challenges in a cold climate. In line with their recommendations, certain additions were made to the final framework regarding the integration of the different lifecycles, the need for intergovernmental coordination, the need to develop construction and demolition material recovery pathways, and the importance of digital information systems and supporting infrastructure for the implementation of the Circular Economy.

Discussion

The results of the comparative policy analysis indicate that there is a fragmented approach to the implementation of the Circular Economy in the different provinces of Canada. For instance, each province has unique regulatory mechanisms, priorities, and levels of CE adoption. Some provinces have highly advanced circular economy strategies and plans in place for the construction industry, leading to variations in the implementation of circular construction strategies.

Provinces of Quebec and Ontario have adopted most measures to follow the circular economy in the construction sector, whereas in some provinces, several municipalities have also created roadmaps for the construction industry. These strategies include initiatives that promote material recovery, reuse, and recycling in construction. Additionally, there are some municipalities that have adopted unique circular construction strategies. More importantly, the lack of a federal framework further amplifies these differences through interprovincial coordination and standardization. A lack of coordinated and integrated CE transition in Canada results in isolated innovation, inefficiencies, redundancies, and under-integration of cross-sectoral elements, especially between construction and energy. This vertical and horizontal policy coordination constrains the emergence of an integrated circular construction system that can tackle national sustainability and climate goals.

Additionally, the research reveals that existing CE policies are narrow in scope and limited in practice. Their focus on downstream recycling and diversion (waste management) is a narrow view of circularity that overlooks upstream lifecycle actions. Critical areas such as design-for-reuse, material choice, deconstruction and lifecycle design are poorly integrated into policy. This implies that CE implementation is mainly reactive rather than holistic, focusing on the end of the building lifecycle while neglecting the entire lifecycle.

This gap is compounded by the lack of consideration of cold-climate factors in CE policy. While there is evidence that freeze–thaw cycles, moisture interactions and temperature variations have a profound impact on material performance and building lifespans, such considerations are not integrated into circular construction strategies. The disconnect between building science and policy frameworks suggests a lack of fit between environmental challenges and policy frameworks. This undermines the potential to improve material performance and building lifetimes and reduce lifecycle emissions through climate-sensitive circular design. Overall, these insights indicate that for the CE to flourish in Canada's construction sector, policies need to evolve from disjointed, waste-focused frameworks to holistic, lifecycle-focused governance and policy.

Conclusion and Recommendations

This research offers a holistic evaluation of the current state of circular economy (CE) integration into Canadian construction and energy policies, especially in cold climates. Through a comparative analysis of provincial policies, case studies, and well-established models like ReSOLVE and the 3Rs, this study shows that CE implementation in Canada is fragmented and unequal across jurisdictions and has largely focused on downstream waste management strategies. Although some provinces, such as Quebec, demonstrate more mature and institutionalized practices, most lack construction-specific CE policies, lifecycle considerations, and integrated regulatory frameworks. A key contribution of this research is to pinpoint structural deficiencies in CE. This study's unique contribution is the creation of a multi-layer conceptual framework that brings together the three pillars of governance mechanisms, cold climate performance requirements, and life cycle principles to facilitate the implementation of CE in the building and construction industry in Canada. The research reaffirms the importance of addressing policy silos, regulatory inconsistencies, and the lack of targeted incentives that hamper circular construction. Although freeze–thaw cycles, material degradation, energy use, and remote-supply logistics are critical considerations for CE, they are not explicitly accounted for in current CE policies and practices, limiting the effectiveness of Circular Economy implementation in Canada’s cold-climate construction sector.

The findings of this study have several implications. To support the shift towards a circular construction system in Canada, greater interprovincial policy coordination, the integration of lifecycle principles and material recovery into building codes and standards, and the development of reuse markets, material tracking, and reverse logistics infrastructure. Furthermore, CE policies must embed cold climate durability and energy efficiency as central parts of the policy rather than being treated as secondary considerations. Overall, the research suggests that the alignment of policies, incorporation of lifecycle thinking into building codes, and the development of infrastructure and markets that enable the reuse of materials need to be improved to realize circular construction in Canada. A more integrated, lifecycle-focused approach is needed to achieve sustainability, energy efficiency, and resilience in cold-climate construction.

The results indicate that Canadian governments should develop a harmonised circular economy policy, incorporating lifecycle principles, the specific requirements for cold climates, and construction-specific policies. Policymakers should enhance interprovincial cooperation, encourage material reuse and reverse logistics support, establish digital material tracking systems and support, and offer specific incentives for circular construction.

The study has a few limitations. Firstly, the proposed framework has not yet been validated in practice through implementation in real-world construction projects. Second, the results are derived from a policy comparison and initial expert validation and may limit the generalizability of the findings to other jurisdictions and contexts. Lastly, there can be selection bias, as the authors or subject matter experts are selected with a clear purpose.

The framework needs to be empirically tested with longitudinal case studies and pilot implementation projects in various Canadian provinces in the future. Further research is needed to assess how effective the framework is in enhancing the performance of the circular economy, policy integration, resource efficiency, and sustainability outcomes across various climatic and regulatory contexts.

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